Cassava - Based Cropping Systems Research 1

International Institute of Tropical Agriculture

PROCESSING, UTILIZATION AND NUTRITIONAL LINKAGES FOR CASSAVA-BASED SYSTEMS IN VARIOUS ENVIRONMENTS

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During the 1980s, cassava has been receiving increasing attention from international groups. UNICEF has cited it as a crop for "household food security" as indicated in a policy shift from primarily health and immunization programs to improved cropping systems and the use of "social mobilization" in introducing improved cassava varieties and food products. A US$40 million program on cassava multiplication, with support from the International Fund for Agricultural Development (IFAD) and the World Bank, was started this past year in Nigeria. In August 1987, the International Food Policy Research Institute (IFPRI) organized a workshop in Washington, D.C., on "Trends and Prospects of Cassava in the Third World" to round off this interest in cassava by international donors.

Some skepticism has been voiced concerning this reported attention to cassava research. Many observers wonder whether it is because the crop does not compete with U.S. and European produce and is thus safe for further development. More positive opinions stress that cassava has been grossly underresearched and underdeveloped, and that appropriate processing, improved storage, and inter-country marketing have vast potential for the urban African population. The research concentration has so far been on the production aspects.

The purpose of this paper is to highlight the linkages among utilization, processing, and nutrition, and the reasons why these factors must be reincorporated as an integral part of cassava research in varying environments. Recognizing and reducing the enormous crop losses that occur between harvesting and final use can significantly contribute to improving the supply of agricultural products above and far beyond what may be achieved by increased primary production (Booth 1974).

Cassava possesses many merits as an insurance crop, but it also presents constraints, particularly as an energy food. Losses during storage are high and the crop is highly perishable. In addition, the arduous processing necessary requires much labor, particularly female.

Roots and tubers: food consumption in Africa

For countries such as Central African Republic, Congo, Mozambique and

Zaire, cassava provides 70 percent of the caloric intake, and an average total of 407.4kg is consumed annually per inhabitant (Dorosh 1987; Gebremeskel and Oyewole 1987). Cassava ranks far above any other roots and tubers or cereals in consumption both in these four countries, which constitute Group I in table 1, and in the countries of Group II.

Table 1. Staple food consumption (kg per inhabitant) in sub-Saharan Africa, 1981-83, by group

	Group I	Group II	Group III	Total
		kg per inhabitant		
Roots: total	**427.2**	**234.9**	**43.1**	**182.4**
Cassava	407.4	123.0	21.3	117.8
Yam	6.6	72.4	3.5	36.8
Sweet potato	6.6	20.3	5.0	12.5
Others	6.6	19.2	13.3	15.3
Plantain	26.2	39.1	2.0	22.7
Cereals	39.7	83.8	134.1	98.3
		% equivalent calories		
Roots: total	**74**	**43**	**8**	**35**
Cassava	70	22	4	24
Yam	1	14	4	7
Sweet potato	2	3	1	2
Others	1	4	3	2
Plantain	4	6	—	4
Cereals	22	51	91	61

Source: FAO.

Note: These countries are grouped as follows:
Group I: Central African Republic, Congo, Mozambique, Zaire.
Group II: Angola, Benin, Burundi, Cameroon, Comores, Guinea, Gabon, Ghana, Côte d'Ivoire, Nigeria, Rwanda, Tanzania, Togo, Uganda.
Group III: Botswana, Burkina Faso, Cape Verde, Chad, Ethiopia, Gambia, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Namibia, Niger, Réunion, São Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Zambia, Zimbabwe.

Cassava accounts for about 1,200 calories per capita per day (about half of total calories) in Zaire and the Congo and more than 900 calories per capita per day in the Central African Republic. On the basis of FAO Food Balance Sheets, it is estimated that "there are 40 million people living in Central Africa and Mozambique whose average daily cassava consumption exceeds 600 calories per day, and another 120 million people (throughout Africa) whose average daily cassava consumption exceeds 200 calories per day" (Dorosh 1987).

Cassava as a staple

Cassava has some distinct disadvantages. The protein content is only 1 percent of fresh weight and 3 percent on a dry matter basis. This protein content compares unfavorably with other roots and tubers: white potato has 9 percent, sweet potato 4.3 percent and yam 8.7 percent protein. Compare this with the 40 percent protein content of soybeans. Cassava has a moisture content of between 60 and 70 percent, which increases transport costs, and a very short post-harvest storage life. The losses have been estimated at 14 to 75 percent (Janssen and Wheatley 1985). A more conservative estimate suggests that around 25 percent of all perishable food crops harvested are lost before they are consumed. Nevertheless, the potential long-term ground storability of cassava is a distinct advantage. Deterioration, manifest in loss of quality and quantity, results from pathological, physiological, or mechanical damage (Booth 1973). Because cassava can be stored for only two or three days after harvest, it is left in the ground until needed and then is consumed or processed immediately. According to calculations given by Ingram and Humphries (1972), if only half the global cassava crop is left in the ground for as little as two months longer than necessary, more than 8 percent of the total area planted to the crop is unnecessarily occupied, assuming a 12-month growing season. Thus, on a global basis of just over 9 million hectares cropped with cassava, about three quarters of a million hectares of agricultural land are withheld from alternative production. Cassava is usually available all year round thanks to this practice of "storage avoidance" (Intermediate Technology Development Group 1987).

Cassava nutritional drawbacks are its low protein content, low energy density, and potential toxic effects from the natural content of cyanide-yielding compounds (Jaynes 1987). The first of these can be effectively counteracted with protein-rich supplementary food and the second with energy-dense supplementary food (Rosling 1987).

As reported by Dr. Jesse Jaynes, the cassava root contains 30-40 percent dry matter, composed mainly of starch and sugar, which is found in a higher proportion than in most other roots and tubers. Thus cassava is an admirable source of calories, but its low protein content and the extremely poor quality of the protein it does contain make it an incomplete food (see table 2).

Table 2. Dry matter, carbohydrates, and protein content of root and tuber crops

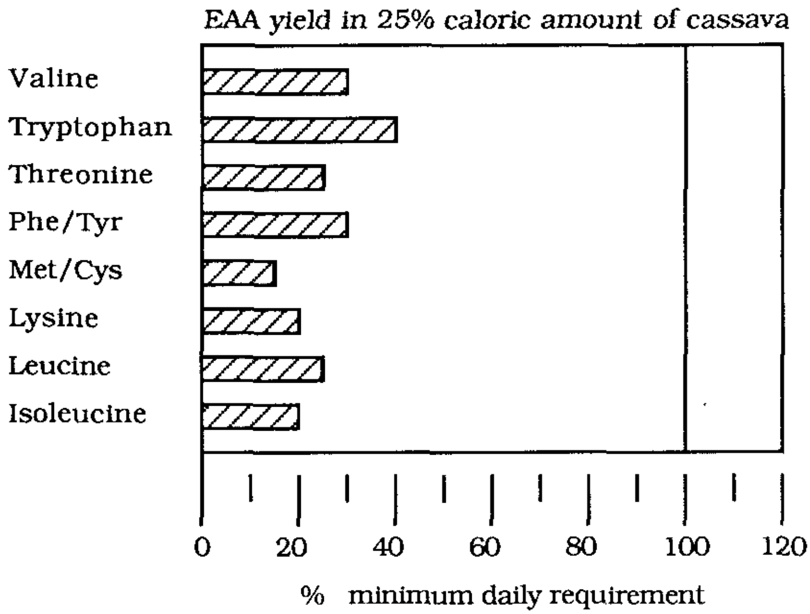
Crop	Dry matter (%)	Carbohydrate (% dry matter)	Protein (% dry matter)
Cassava	37.5	92.5	3.2
White potato	22.0	85.9	9.1
Sweet potato	30.0	91.0	4.3
Yam	27.6	87.3	8.7
Taro	27.5	84.4	6.9

Source: Jaynes 1987

Figure 1 shows that cassava is extremely deficient in certain essential amino acids. It has been difficult to produce significant increases in the essential amino acid content of cassava by means of classic plant-breeding approaches (Jaynes 1987).

Rosling (1987) showed that toxicity in cassava is caused by the poison cyanide (prussic acid), which has the simple chemical structure HCN. Toxic effects occur when cyanide is liberated from a more complex chemical compound called linamarin. Dietary cyanide exposure from cassava will result from consumption of insufficiently-processed roots, probably from liberation of cyanide in the gut from ingested linamarin. The human body has a fairly effective thiocyanate (SCN). The substrate for this reaction is sulfur (S) originating from proteins in the diet; so if the protein intake is adequate, the human body can withstand moderate cyanide exposure without any symptoms of accumulated effects. But cassava has a low protein content, and, especially during droughts, poor families will also have a low intake of protein-rich supplementary food. The toxic effects of ingested cyanide may thus be aggravated by a low sulfur intake.

Figure 1. Essential amino acid yield in the amount of cassava necessary to yield 25 percent of the caloric requirement of a 20-kg child (about 325 g)



Rosling explains the incidences of goiter and cretinism (a form of mental retardation) as caused by iodine deficiency. These disorders can be considerably aggravated by continuous dietary cyanide exposure from insufficiently-processed cassava. This effect is caused by the detoxication product thiocyanate which interferes negatively with iodine uptake in the thyroid gland. Paralysis of both legs, caused by permanent damage to the spinal cord, has been associated with a combination of a high cyanide and a low sulfur intake from diets dominated by insufficiently-processed cassava and lacking protein-rich supplementary food. The disease, named Epidemic Spastic Paraparesis, has in the last decade crippled 5,000-10,000 women and children during periods of food shortages in cassava-dominated areas in Zaire, Tanzania, and Mozambique. For lack of other foods, the affected families had to consume newly-harvested cassava roots without processing normally; more than one week is required to remove cyanide effectively (Rosling 1987).

The historical association of cassava consumption with kwashiorkor in weaned infants in tropical Africa and Brazil rests on the very low protein content and the frequently simultaneous absence from the diet of satisfactory sources of supplementary protein.

It is essential to understand the cyanogenic effects of poorly processed cassava to ensure proper processing for the crop's development. Nevertheless, as a household food security crop, the advantages of cassava production and use certainly outweigh the disadvantages. The following factors are put forward for consideration as national collaborators initiate a program on cassava post-harvest technologies and utilization.

Factors to consider when collecting and interpreting relevant data related to cassava utilization, processing and nutrition

1. Socioeconomic-nutritional base-line surveys that determine the importance and trends in cassava production and use within production system. Particular attention should here be focused on the methods of cassava preparation for household use; market sales for feed, food, or industrial use; prices of cassava products vis-à-vis other competing crop products; measured nutritional value of various cassava-based foods and potential for introducing new cassava-based foods, both for household and commercial use.

2. On-farm research to include a nutritional and health assessment component for cassava-based regions. The most common sets of indicators are mortality statistics and anthropometric measurements. Keep in mind that children from birth to three years suffering from third-degree malnutrition have been found to have mortality rates 6 to 20 times as high as children of normal weight. For anthropometric indices, measurements of weight and height (or supine length for children under two years) are the most sensitive indicators of the nutritional status of infants and young children. In addition, arm circumference can be used for assessment of nutritional status independent of age between six months and four to five years (Austin 1981). Other assessments which non-nutritionists can make include aclinical assessments of hair, eyes, and indications of edema. The most certain assessment is laboratory biochemical analysis of bodily fluids.

3. In terms of the quality of the improved cassava varieties, it will be necessary to determine whether they speed up or slow down processing time and marketing. Data will need to be collected on time allocation and labor use at various stages of cassava development. Careful consideration needs to be given to women's labor and women's response to the improved varieties. Some women's groups in Oyo and Ondo States,

Nigeria, have complained that the larger tubers are more difficult to peel and to market and that they require longer frying because of the high water content.

4. Medical and health-related research needs to be developed on the dangers, particularly to pregnant women and children who inhale fumes during the frying of gari.

5. What are the richer energy foods that can be introduced into a cassava-based system? The potential agronomic and nutritional advantages of introducing soybeans should be considered.

6. Collection and analysis of samples of processed cassava from processing centers to determine the overall quality of product, storage capabilities and mechanical damage on the improved tubers. Research should be done in local traditional settings rather than in sophisticated laboratories.

7. Extent of bitter and sweet varieties in a production system and the incorporation of both varieties into any new system with complementary research on the acceptability of new food products. Oben and Menz have concluded that "the potential benefits from the breeding of improved low cyanide cassava varieties in Nigeria are extremely high relative to the cost" (1980). Their survey indicates the relative importance of sweet cassava in various regions of Nigeria.

One of the primary objectives of the IITA-UNICEF Program on Household Food Security and Nutrition is the development of cassava-based foods from sweet varieties. Primarily indigenous sweet varieties are used and 44 new food products have been developed.

8. A South-South Exchange on the introduction and testing at rural household level of new food products based on Asian preparation techniques and use.

9. Improved efficiency in machinery, particularly for the processing of cassava into gari to cut down on the time women spend in processing. A 1986 IITA survey by Oyewole indicates that a power grater can reduce the time needed to grate 140kg of tubers from 6 hours to 20 minutes.

The development of machinery to cut down on labor requirements is essential. Given the hours spent, particularly by women, cassava is not a low-input crop. A study comparing the percentage of labor input contributions in cassava processing and utilization in five Nigerian states

Table 3. Relative importance of sweet cassava in various regions of Nigeria

State	Sweet cassava as a percentage[a] of total cassava grown (by area)	Percentage[a] of farmers growing only sweet cassava	Percentage[a] of farmers growing both sweet and bitter cassava
Anambra	0	0	0
Bendel	6	0	47
Ogun	21	3	45
Kaduna	97	97	3

Source: Oben and Menz 1980

Note: [a] In a given year

found that women contributed 82 percent of the total requirement (Ikpi et al. 1987). A 1986 IITA-UNICEF Study in Oyo State, Nigeria, indicates that with the introduction and use of new cassava-processing equipment, women can save considerable time. For instance, one processing hour on a machine saves women 21 hours' work each week. Given the average amount of cassava processed by a household in a year in the Oyo State areas surveyed, with appropriate cassava processing equipment, each family could save an average of 441 hours of work (Ikpi et al. 1986).

10. National research on genetic engineering should be initiated to modify the essential amino acid composition of cassava and thus increase its nutritive value. Priority research attention should be given to supplementing the existing proteins of cassava with new synthetic proteins with a high content of essential amino acids.

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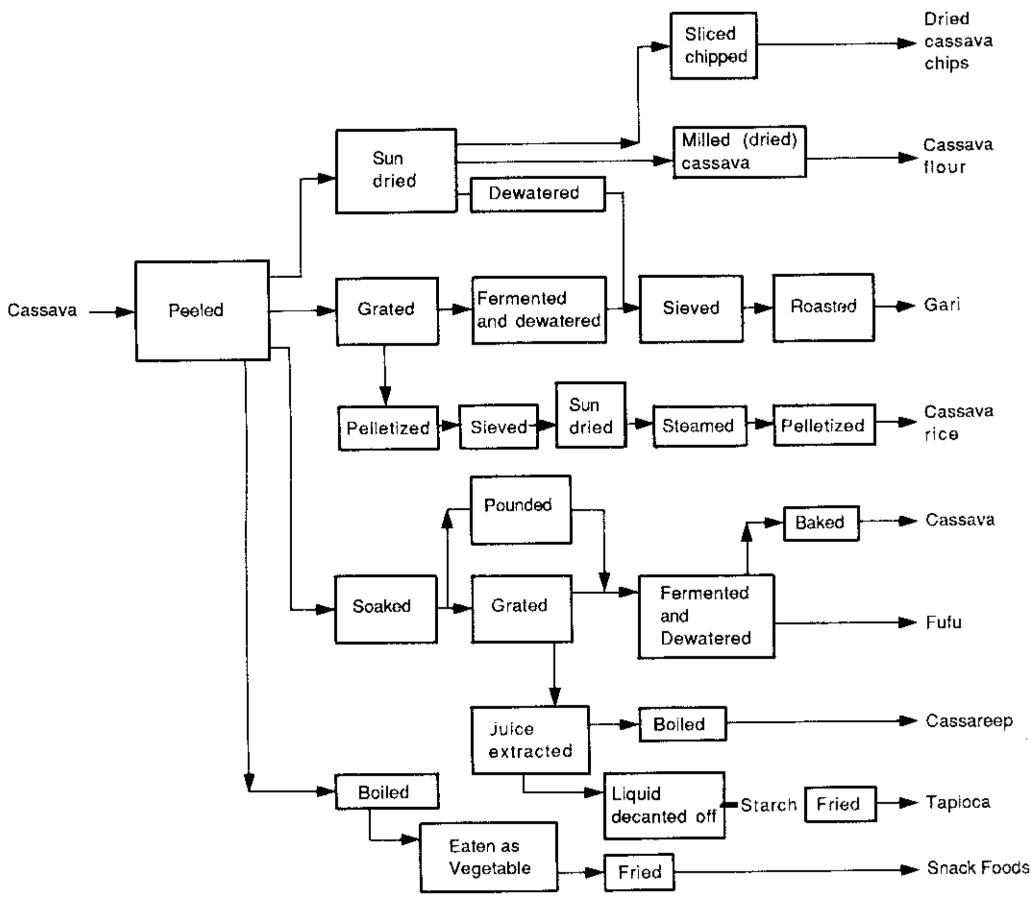
Appendix I. Stages of cassava processing



Source: UNIFEM/WAFT October 1987

Appendix II. Source of calories (%) by commodity group (1977)

Source of calories	All developing countries	Developing market economies: Africa	Latin America	Near East	Far East
Vegetable products	90.9	93.4	82.6	90.5	94.3
Animal products	9.2	6.6	17.4	9.5	5.5
Cereals	60.6	47.4	39.4	61.5	67.2
Wheat	16.2	10.4	14.8	40.1	14.5
Rice	28.6	5.8	9.5	7.2	40.2
Maize	7.7	13.6	14.4	6.3	4.4
Millet and sorghum	6.1	13.8	0.3	5.8	6.9
Roots and tubers	7.2	20.0	6.2	1.7	3.2
Sugars and honey	6.9	4.5	17.2	9.5	8.3
Pulses	4.2	4.2	4.4	2.7	4.4
Nuts and oilseeds	2.2	3.4	0.7	1.8	2.1
Vegetables	1.5	1.0	0.9	2.2	1.4
Fruit	2.1	4.3	4.8	4.0	1.7
Meat, eggs, fish, milk	7.8	5.7	15.0	7.4	4.3
Oils and fats	5.9	7.2	8.2	8.5	6.2
Miscellaneous	1.7	2.4	3.1	0.6	1.0
Total Kcal/day	2 260	2 205	2 557	2 620	2 028

Source: FAO Food Balance Sheets

Richard Longhurst and Michael Lipton, Secondary food crops and the reduction of seasonal food insecurity: the role of agricultural research. IFPRI/FAO/AID workshop on "Seasonal Causes of Household Food Insecurity: Policy Implications and Research Needs," 10-13 December 1985, Annapolis, Maryland.

Appendix III. Source of calories (%) by season in three Zaria villages in northern Nigeria, 1970-71

Food Group	Apr-May	Jun-Jul	Aug-Sep	Oct-Nov	Dec-Jan	Feb-Mar
Cereals	77.4	67.8	67.4	75.5	65.2	63.4
Cereal products	6.0	12.7	8.5	5.5	10.4	16.2
Starchy roots	0.6	2.2	5.1	2.2	1.6	1.8
Milk	1.0	1.3	1.2	1.0	0.8	0.9
Meat	0.4	1.0	0.4	1.1	1.0	1.5
Poultry, fish, eggs	0.0	0.0	0.0	0.5	0.0	0.1
Seeds, nuts, legumes	2.9	4.7	6.0	2.7	5.0	3.5
Fats and oils	9.1	7.5	7.6	8.1	12.6	9.9
Vegetables, fresh	0.2	0.5	1.6	0.8	0.4	0.3
Vegetables, dry	1.2	1.1	1.0	1.1	1.2	1.1
Fruits	0.4	0.0	0.0	0.1	0.0	0.0
Sugar, sweets	0.2	0.4	0.2	0.4	0.7	0.5
Salt, spices	0.0	0.0	0.1	0.1	0.0	0.0
Snacks, Misc.	0.6	0.9	1.3	1.0	1.1	0.7
Total calories intake Kcal	2 457	2 311	2 456	2 274	1 951	2 137

Source: Calculated from E.B. Simmons, Calorie and Protein Intakes in Three Villages of Zaria Province, May 1970-June 1971. Samaru Miscellaneous Paper 55. Ahmadu Bello University, Zaria, (1976), 11 and 129.

Richard Longhurst and Michael Lipton, Secondary food crops and the reduction of seasonal food insecurity: the role of agricultural research. IFPRI/FAO/AID workshop on "Seasonal Causes of Household Food Insecurity: Policy Implications and Research Needs," 10-13 December 1985, Annapolis, Maryland.

Appendix IV. Percentage labor input contribution of females and males in cassava production and processing activities

Activity	(1) Anambra		(2) Bendel		(3) Benue		(1) Cross River		(1) Oyo		Approx. average for Nigeria	
	F	M	F	M	F	M	F	M	F	M	F	M
Field preparation	20	80	60	40	25	75	30	70	35	65	34	66
Planting	90	10	80	20	75	25	70	30	70	30	77	33
Weeding	90	10	100	—	75	25	90	10	75	25	86	14
Harvesting	80	20	90	10	75	25	80	20	60	40	77	23
Processing	100	—	100	—	100	—	100	—	100	—	100	—
Storage	100	—	100	—	100	—	100	—	100	—	100	—
Marketing	100	—	100	—	100	—	100	—	100	—	100	—
Overall Average	83	17	90	10	79	21	81	19	77	23	82	18

Source: J. A. Ekpere, A. E. Ikpi, G. Gleason, T. Gebremeskel, IITA-UNICEF Consultation on Promotion of Household Food Production and Nutrition, 2-8 March 1986, IITA, Ibadan, the place of cassava in Nigeria's food security, rural nutrition and farm income generation: A situation analysis for Oyo State, Nigeria.

Calculated and compiled by Dr A. Ikpi, Senior Lecturer, Agricultural Economics Department, University of Ibadan from (1) Ongoing field surveys in Anambra, Cross River and Oyo State, 1985-86; (2) Grace O. Udele "Rural women in agricultural marketing—case study of cassava in Isoke Local Government Area, Bendel State," MSc thesis University of Ibadan, for the Bendel State figures and (3) Mary E. Burfisher and Nadine R. Horenstein "Sex roles in the Nigerian Tiv farm households" for the Benue State figures (1981).

COMMENTS ON THE THEME TOPIC : "LINKING SIMILAR ENVIRONMENTS"

1. *H.J.W. Mutsaers*

The emphasis in this section was "similar environment". The first objective should be to ascertain how similar, how different and what key factors are responsible and how the information can be gathered. The papers provided too much data. there should be a minimum set of data perhaps at different levels of the environments, eg, broad zones within which selected regions are identified for research with which specific research sites are identified.

2. *J. Smith*

The first question should be an identification of purpose of data collected. It could be for production-function analysis, adoption studies etc. The research objectives determine which data to emphasize. The paper did not address comparison across countries, given different currencies. What exchange rate should be used to compare data meeting terms? One may examine possibilities with shadow exchange rates, ratios of wage rate to price of commodity. If the wage rate is low compared with price of cassava, there will be more incentive to produce cassava.

3. *O. Olorunda*

Cassava is increasingly becoming an industrial, not just a food, crop. There is a need to emphasize end use. Flexibility of harvest time affects end product quality and quantity, eg, water content and garification rate. Most products derived from cassava are affected by pre-harvest factors.

4. *D.S.C. Spencer*

While noting the danger in oversimplification in data collection, especially when research/survey objectives are not fully observed, the set of data suggested in the papers is too broad. Groups may define a minimum data set for activity groups, for example, in the following areas:

(a) Constraints analysis
(b) Experimental station studies
(c) Research managed studies
(d) On-farm studies

The objective should be to ascertain how similar or different various research sites are, and what minimum sets of data are needed to characterize the environments. It is perhaps more practical to consider only agroclimatic data in a broad sense and link socioeconomic data with specific use intended for data collected.

Diagnostic survey results presented showed two trends: those based purely on qualitative data and those based on quantitative data as well. For the collaborative research objectives, quantitative data should be routinely collected by the survey group themselves, eg, field area and yield.